University of Pennsylvania Center for Science, Sustainability, and the Media (PCSSM)

COP28 PRIMER: Direct Air Capture (DAC) and its Fatal Flaw

Direct air carbon capture and storage (DACCS) pulls CO_2 directly out of the air and stores it underground. As global emissions have soared to 50 billion tons (Gt) of CO_2 equivalent, carbon dioxide removal strategies like DAC have generated great interest.

DAC generally uses enormous fans to push large volumes of air over a sorbent that absorbs CO_2. Then, a great deal of energy is needed to release the CO_2 and regenerate the sorbents. The efficiency of this process is low (5% to 10%), and the price is high because CO_2 in the air is so diluted—420 parts per million. **The entire Houston Astrodome contains only about 1 ton of CO_2**.

DACCS is costly, $600 to $1000 a ton of CO_2. Whether it could ever approach the U.S. target of under $100/ton is unclear. In a June talk, the co-CEO of industry leader Climeworks, "told the crowd his company could see its **prices remain as high as $300 by 2050**." Other studies have similar conclusions. In the unlikely event we did hit $100, it would cost $22 trillion to reverse warming by only 0.1°C.

THE FATAL FLAW WITH DAC RIGHT NOW

Media coverage has generally ignored the biggest flaw with DAC. The vast renewables needed for DAC would reduce far more emissions for far less money for decades by using them to directly replace fossil fuels in power plants, vehicles, and other sectors. As a 2022 review by the "collective voice of European science" explained, "**up to 20 times as much energy is required to remove a tonne of CO_2 from the atmosphere than to prevent that tonne entering in the first place**."

DAC only lowers CO_2 if it runs on renewables (or nuclear). Yet a 2023 analysis concluded, "**Coupling DACS to intermittent renewables is typically not favorable for low costs**."

Also, a 2021 analysis explained, "**Only when the region's electricity system is nearly completely decarbonized, do the opportunity costs of dedicating a low-carbon electricity source to DAC disappear**." Another analysis found **using renewables to power electric vehicles (EVs) is far more cost-effective at reducing CO_2 than using them to power DAC**.

A 2019 report on negative emissions technologies (NET) by the U.S. National Academy of Sciences made the same point: "**The committee repeatedly encountered the view that NETs will primarily be deployed to reduce atmospheric CO_2 after fossil emissions are reduced to near zero**." NETs would be used sooner only if they delivered emissions reductions much more cheaply.

So, DAC will be a costly misuse of renewables for the foreseeable future. A lot of renewables. A 2020 review noted that by one estimate "**renewables-powered DAC would require all of the wind and solar energy generated in the U.S. in 2018 to capture just 1/10th of a Gt [gigaton] of CO_2**."

In its recent *Net Zero Emissions by 2050 Scenario*, the International Energy Agency has less than 0.7 Gt CO_2/year of DACCS removal by mid-century. The IPCC envisions substantially less than that in its 2900-page review of mitigation science from 2022. We should invest in R&D and demonstration of various CO2 removal strategies now, including DAC. But major investments to scale up DAC in the next two decades are unwarranted and would be counterproductive.

UPenn PCSSM primers aim to quickly inform COP28 decision-makers about problems with specific climate solutions.
.Joseph Romm (Rommj@sas.upenn.edu) is the former acting assistant secretary of energy efficiency and renewable energy with a Ph.D. in physics from MIT. He's a UPenn senior research fellow and author of the November report, "Why direct air carbon capture and storage (DACCS) is not scalable and 'net zero' is a dangerous myth.